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NEW LAND-LOCKED FISH SPECIES OF THE GENUS *GALAXIAS* FROM NORTH AUCKLAND, NEW ZEALAND[1]

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ABSTRACT: Two species of *Galaxias* Cuvier (Galaxiidae) are described from small land-locked coastal dune lakes in North Auckland, New Zealand. They are small shoaling species similar to and apparently derived from the sea-going *Galaxias maculatus attenuatus* (Jenyns).

INTRODUCTION

In the New Zealand Galaxiidae, speciation appears to be taking place by the land-locking of sea-going species. This is a pattern familiar in the Northern Hemisphere Salmonidae, and also in the Southern Hemisphere in the Retropinnidae (McDowall, 1965). Stokell (1964) described a new species of *Galaxias* (*G. parrishi*), which he considered to be a land-locked derivative of *G. maculatus ignotus,* and noted another land-locked form from Victoria, Australia. The writer (McDowall, 1966) noted a similar form collected from another Victorian lake (see Pollard, 1964), and the occurrence of further such derivatives from *G. maculatus attenuatus,* in New Zealand coastal lakes.

About 15 years ago, the New Zealand Marine Department conducted a survey of the chain of small lakes on the west coast of the North Island of New Zealand, to determine their ecology in relation to the introduction of suitable game fishes. In their report on this survey, Cunningham et al. (1953) described the fish faunas of these lakes as follows: "Various species of *Galaxias, Gobiomorphus,* and *Retropinna* were recorded," and they listed in a table the lakes from which these genera were taken. In 1963, the writer examined a sample of *G. maculatus attenuatus*-like fishes from one of these lakes, which, on close examination, appeared to be distinct from *G. maculatus attenuatus* in a number of details. Because this sample was rather old, it was felt desirable to recollect the fish, before description, and this was done in March 1965. Large samples of *Galaxias* were collected from Lake Waiparera, a few miles north of Kaitaia, and from Upper Lake Rototuna, on the peninsula west of the northern arm of Kaipara Harbor (Fig. 1). Inasmuch as these lakes are land-locked, it was to be expected that the *Galaxias* populations would differ morphologically and behaviorally from *Galaxias maculatus attenuatus.*

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[1] Fisheries Research Publication No. 93.

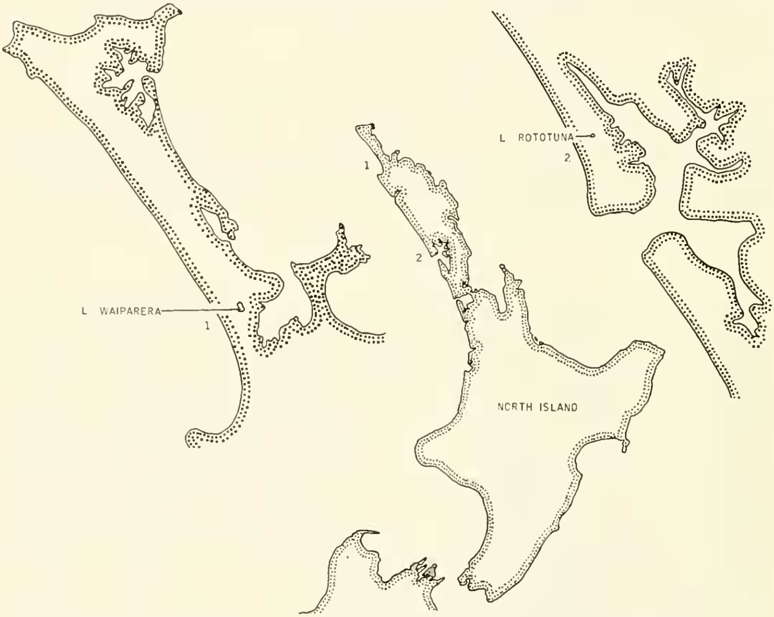

Figure 1. Locality map of North Island, New Zealand, showing location of: 1. Lake Waiparera, 2. Lake Rototuna.

Being land-locked, their life cycles are also necessarily modified from that of *G. maculatus attenuatus* which has marine juveniles.

Examination of the fresh samples from these two lakes, showed them to be distinct from *G. maculatus attenuatus* and from each other. They do not resemble any other New Zealand species of *Galaxias.* Characters suggesting relationship to *G. maculatus attenuatus,* apart from their general appearance and coloration, include shoaling behavior as adults, forked caudal fins, similar dentition, lack of pyloric caeca, and the long, many-rayed anal fin.

The isolation of sea-going species in small lakes, as appears to have taken place in these instances, poses a problem in species delimitation. The alternatives lie between describing each isolate as a distinct species or subspecies, or including all the populations in a single, widely variable species, derived from the parent sea-going species. Since there has been a fundamental change in the life history pattern of the land-locked species, it seems likely that the parent and derivative species have acquired reproductive isolating mechanisms. This conclusion is supported by the fact that the derivative populations have developed characteristic morphological differences from the parent population. The specific distinctness of the two derivative populations under examination is another problem. Ideally, breeding experiments and behavioral studies of the two populations would be desirable to provide the answers, but these are outside the scope of the present study. On examining the morphological differences between the two populations, it seemed likely that they were independently derived from the parent stock and therefore more closely related to the parent than to each other. The population in Lake Rototuna is, from both morphological and geological considerations, probably an earlier derivative of *G. maculatus attenuatus* than is the Lake Waiparera population. Lake Rototuna occurs in well stabilized rolling sand dunes, once covered in bush, at an altitude of 300 ft. (91 m), whilst Lake Waiparera is in still shifting sand dunes, about a hundred feet (36 m) above sea level. Corresponding to their apparent difference in age, and perhaps to differing ecological conditions in the two lakes, the degree to which these species have diverged from their common parent species differs greatly. The differences are most obvious in vertebral count, a character which has proved useful in separating *Galaxias* species in New Zealand. Assuming relationship to *G. maculatus attenuatus,* the Lake Rototuna population has traversed the full range of vertebral number in the New Zealand Galaxiidae, from the maximum in *G. maculatus attenuatus* of 59-64, to a minimum of 47-50. The vertebral number in the Lake Waiparera population is also reduced and almost completely disjunct from both *G. maculatus attenuatus* and the Lake Rototuna population, viz. 54-59 (Fig. 2).

The direction of divergence from *G. maculatus attenuatus,* seen in the two derivatives, varies; sometimes the counted structures are fewer in number, as in vertebrae and most of the fin-ray counts (Fig. 3). In the case of gill rakers (Fig. 2), in contrast, *G. maculatus attenuatus* has a total count on the first arch of 13-17, the Waiparera fish 15-17, and the Rototuna fish 18-23. These data

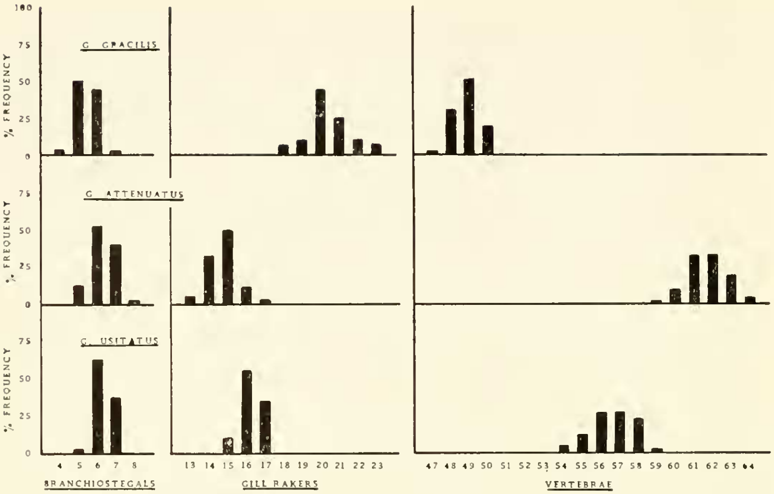

Figure 2. Frequency distribution for counts of branchiostegals, gill rakers, and vertebrae in *Galaxias gracilis, G. maculatus attenuatus,* and *G. usitatus.*

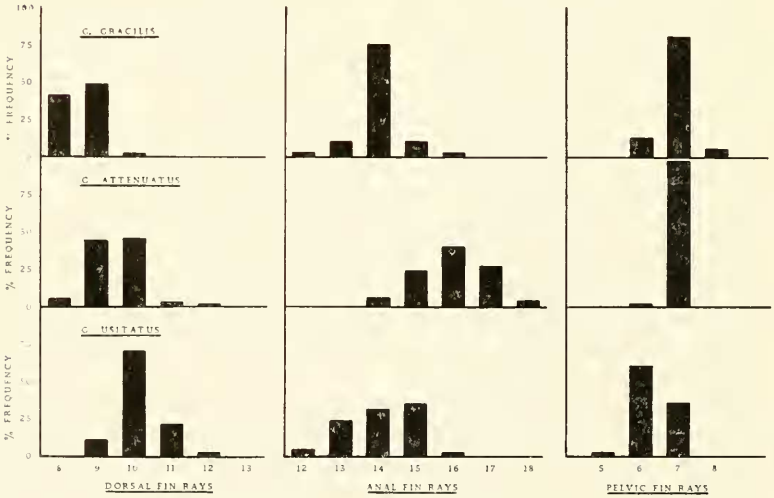

Figure 3. Frequency distribution for counts of dorsal, anal, and pelvic fin rays in *Galaxias gracilis, G. maculatus attenuatus,* and *G. usitatus.*

suggest that the meristic distinctions may not be simply a case of temperature related differences. Differences were also found to occur in body proportions. In some cases both the derivatives diverged from *G. maculatus attenuatus* in the same direction (Fig. 4-2, 4-5), the measured structure being proportionately either

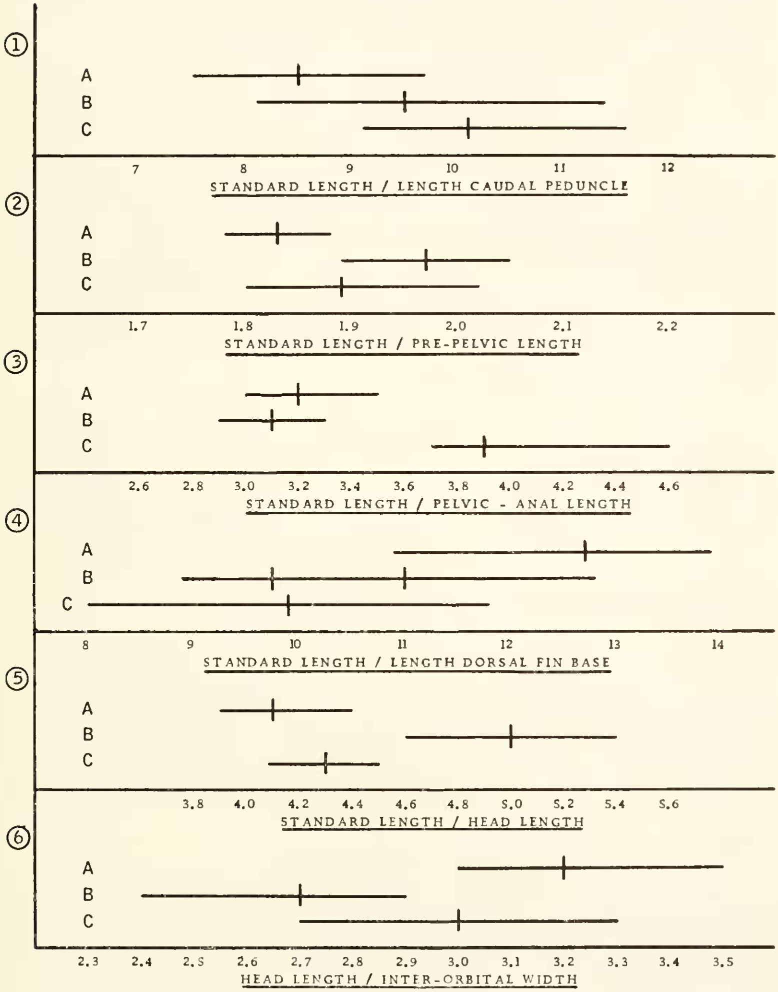

Figure 4. Ranges for proportional measurements in *Galaxias gracilis* (A), *G. maculatus attenuatus* (B), and *G. usitatus* (C).

larger or smaller in both derivatives than in *G. maculatus attenuatus*. In other cases, the divergence has gone in opposite directions, and the range for *G. maculatus attenuatus* was found to lie between the ranges for the derivative populations (Figs. 4-1, 4-4).

These data indicate that each of the two populations should be regarded as a full species, distinct from *G. maculatus attenuatus* and from each other.

SYSTEMATIC DESCRIPTION

GALAXIAS GRACILIS[1] n.sp.

Figure 5; Table 1a.

Holotype: Deposited in collection of Fisheries Research Division, New Zealand Marine Department.

Paratypes: Dominion Museum, New Zealand. Reg. No. 4499; Museum of Comparative Zoology, Harvard University, No. 45053; Smithsonian Institution Fish Collection No. USNM 201224.

Type locality: Upper Lake Rototuna, Kaipara Harbour, North Auckland, New Zealand.

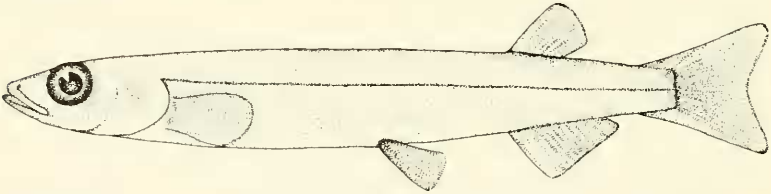

Figure 5. *Galaxias gracilis* n.sp. Length to caudal fork, 59 mm.

Description: A small, slender, shoaling species with long head, low vertebral count and rearward placement of the pelvic fins. Maximum known fork length 62.5 mm. D i-iii, 7-10; C 16; A i-iii, 12-16; Pel 6-8; Pec 12-14; Branchiostegals 4-6; Vertebrae 47-50; Gill-rakers 5-7 (upper), 13-17 (lower limb of first arch), total 18-23.

Trunk cylindrical, slender, somewhat depressed on head, laterally compressed on caudal peduncle, deeper than broad. Caudal peduncle slender and short. Head small, slender, a little broader than deep, lower jaw protruding a little, or equal in length to upper; lips thin, cleft of mouth slightly oblique, extending to a line through anterior eye margin. Eye large, at upper head profile, with inter-orbital flat.

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[1] Named on account of its slender form, from the Latin *gracilis,* slender.

Mandibular and premaxillary teeth without canines, lingual teeth strong, entopterygoidal teeth moderately developed; gill-rakers strongly developed; pyloric caeca lacking.

Fins membranous and short, except anal which is long based. Distal margin of dorsal fin rounded to straight, anterior rays longest. Anal origin more or less below dorsal origin, distal margin of fin straight, anterior rays longest, maximum fin length little longer than base length. Pelvic fins inserted relatively far back, pelvic-anal interval short, fin relatively short in pelvic-anal length. Pectoral fin disposed laterally, fin short. Caudal fin forked, fin tips rounded, depth about equal to body depth.

Coloration: Trunk covered with a dense peppering of large melanophores, which intensify on the head and dorsum of the trunk, failing lateroventrally, and ventrally. Fresh material is silver in these latter areas.

Meristic variation: Dorsal rays (segmented), 7(1), 8(21), 9(23), 10(5); Caudal 15(4), 16(42), 17(4); Anal 12(1), 13(5), 14(30), 15(13), 16(1); Pelvic 6(7), 7(40), 8(3); Pectoral 12(8), 13(28), 14(14); Vertebrae 47(1), 48(16), 49(24), 50(9); Branchiostegals 4(2), 5(27), 6(21); Gill-rakers (total count) 18(2), 19(3), 20(13), 21(7), 22(3), 23(2).

Differs from *G. maculatus attenuatus* (Jenyns) in having a much lower vertebral count, fewer dorsal rays, a somewhat lower branchiostegal count and more gill rakers; also in a longer pre-pelvic length, longer head, narrower inter-orbital, larger eye, short dorsal fin base, smaller maximum size reached, and the lack of a marine whitebait juvenile stage. Differs from *G. usitatus* n.sp. in having fewer vertebrae, fewer branchiostegals, a greater number of gill rakers, a longer pelvic base-anal origin length, shorter dorsal fin base, lack of serrations on the opercular membrane and the smaller maximum size attained.

GALAXIAS USITATUS[1] n.sp.

Figure 6; Table 1b.

Holotype: Deposited in collection of Fisheries Research Division, New Zealand Marine Department.

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[1] Named on account of its lack of highly distinctive characters, from the Latin *usitatus,* ordinary.

Paratypes: Dominion Museum, New Zealand Reg. No. 4500; Museum of Comparative Zoology, Harvard University, No. 45054; Smithsonian Institution Fish Collection No. USNM 201223.

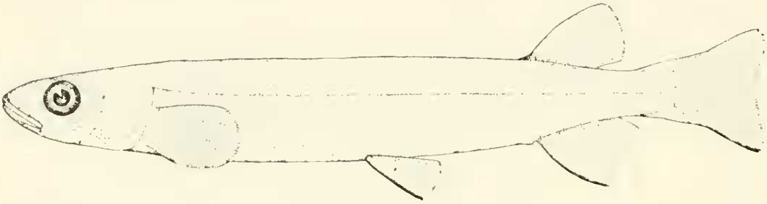

Figure 6. *Galaxias usitatus* n.sp. Length to caudal fork, 72 mm.

Type locality: Lake Waiparera, North Auckland, New Zealand.

Description: A slender, lacustrine, shoaling species, similar to *Galaxias maculatus attenuatus,* with long head, a short pelvic-anal interval, with many of the fishes examined having six rather than the more usual seven pelvic fin rays. Distinctive in the presence of fine but definite serrations on the free margin of the opercular membrane. Maximum known fork length 81.5 mm. D i-iii, 9-12; C 14-18; A ii-v, 12-16; Pel 5-7; Pec 11-15; Branchiostegals 5-7; Vertebrae 54-59; Gill-rakers 4-5, 11-13, total 15-17.

Trunk cylindrical, slender, somewhat depressed on head, laterally compressed on caudal peduncle and somewhat deeper than broad. Caudal peduncle slender and short. Head long and narrow, slender, about as deep as broad; jaws equal, prominent, cleft slightly oblique reaching to about anterior eye margin, gape rather narrow. Eye large, placed close to upper head profile, inter-orbital more or less flat, broad relative to head width. Mandibular and maxillary teeth without canines, lingual teeth strong, entopterygoidal teeth well developed; pyloric caeca lacking; gill rakers well developed; free margin of operculum finely serrate.

Fins membranous and short, except anal which is long based. Dorsal fin set well back, fin with moderately short base, distal margin of fin somewhat rounded. Anal fin origin more or less below dorsal origin; anal fin long based but greatest fin length little greater than base length, distal margin of fin about straight and inclined to body axis. Pelvic fin inserted at about mid-point of standard length, pelvic-anal length short, pelvic fin moderate in pelvic-anal interval, thus short. Pectoral fin base disposed laterally, fin short. Caudal fin forked, fin tips rounded, fin depth about equal to body depth.

Coloration: Trunk a dusky gray-brown and covered with irregular dark blotches similar to *G. maculatus attenuatus.* When alive, the lateroventral and ventral abdomen is silvery, in preserved material, largely unpigmented.

Meristic variation: Dorsal rays (segmented) 9(4), 10(28), 11(8), 12(1); Caudal 14(1), 15(4), 16(34), 17(1), 18(1); Anal 12(2), 13(10), 14(13), 15(15), 16(1), Pelvic 6(30), 7(11); Pectoral 11(1), 12(5), 13(21), 14(12), 15(2); Vertebrae 54(2), 55(5), 56(10), 57(12), 58(9), 59(3); Branchiostegals 5(1), 6(25), 7(15); Gill-rakers 15(2), 16(11), 17(7).

Differs from *G. maculatus attenuatus* in having a lower vertebral count, fewer pelvic fin rays, longer head, somewhat larger eye, shorter pelvice-anal interval; differs from *G. gracilis* in details discussed under the diagnosis of that species. It differs from both *G. maculatus attenuatus* and *G. gracilis* by the presence of serrations on the opercular margin.

DISCUSSION

The two new species described above are interpreted as landlocked derivatives of one of the New Zealand sea-going species, *G. maculatus attenuatus.* In Lake Okataina, thermal lakes district, North Island, and in one of the Kaihoka Lakes, near Cape Farewell, there are two land-locked populations of the sea-going *G. fasciatus* Gray. The upland-alpine lake species *G. koaro* Phillipps and *G. lynx* Hutton are also envisaged, by the writer, as freshwater derivatives of *G. brevipinnis* Günther, a species with marine stages. It was suggested (McDowall, 1965), that *Retropinna abbreviata* McDowall and *R. lacustris* Stokell had speciated under similar circumstances — in isolation, in lakes cut off from the sea with a migratory population captured in the impounded water body. Looked at from this perspective, the distribution patterns of some of the apparently younger species in New Zealand's freshwater fish fauna make greater sense, e.g. *G. lynx,* present in alpine lakes all along the eastern side of the main divide of the South Island, to the west of the divide in the Nelson Lakes district, with, according to the arrangement of Stokell (1949) a highly disjunct population in Lake Waikaremoana, near East Cape in the North Island. This pattern appears best explained by derivation of the freshwater lacustrine form, probably several times, from the parent species *G. brevipinnis. G. koaro* probably has the same mode of derivation, from *G. brevipinnis,* one or several times, in the lakes of the volcanic plateau of the North Island, and further study may well suggest that *G. lynx* and *G. koaro* are conspecific.

This view of speciation in the Galaxiidae probably supplies the key to understanding much of the fauna, both phylogenetically and zoogeographically.

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TABLE 1.

Morphometric variation in *Galaxias gracilis* and *G. usitatus.*

Ratio	a. *G. gracilis*	b. *G. usitatus*
Standard length/Body depth at vent	8.25-9.50	7.70-10.08
Standard length/Caudal peduncle length	7.46-9.65	9.14-11.60
Caudal peduncle length/Peduncle depth	1.54-2.08	1.31-1.69
Pre-dorsal length/Standard length	0.73-0.78	0.74-0.79
Standard length/Dorsal fin base length	10.90-13.86	8.00-11.78
Dorsal fin length/Fin base length	1.38-1.71	1.29-1.64
Standard length/Anal fin base length	6.44-7.68	6.02-8.20
Anal fin length/Fin base length	1.11-1.33	1.15-1.33
Pre-pelvic length/Standard length	0.53-0.56	0.49-0.56
Pectoral-pelvic length/Standard length	0.28-0.33	0.28-0.33
Pectoral fin length/Pectoral-pelvic length	0.32-0.42	0.36-0.43
Pelvic-anal length/Standard length	0.20-0.24	0.22-0.27
Pelvic fin length/Pelvic anal length	0.41-0.50	0.36-0.43
Standard length/Head length	3.92-4.39	4.06-4.54
Head length/Head width	1.87-2.14	1.87-2.29
Head length/Inter-orbital width	3.01-3.50	2.67-3.25
Head length/Eye diameter	3.67-4.50	3.72-4.58
Head length/Gape width	3.29-4.00	2.90-3.80